A REPORT ON THE SOUTHERN CALIFORNIA FOREST BAT SURVEY AND RADIO-TELEMETRY STUDY OF 1996

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INTRODUCTION

The U.S. Forest Service, as part of the Southwestern California Ecoregion Coordinating Group, is attempting to develop a Multi-species Conservation Strategy for Forest and Woodland Habitats in Southern California. The objective of this effort is to develop an ecosystem-based strategy that will facilitate the recovery of listed species and the protection of candidate and former candidate species. The alternative conservation strategies are to be based on predictive, spatially explicit models of habitat suitability. However, recorded information is lacking on the distribution or habitat relationships of sensitive bat species to construct adequate models. To this end, Brown Berry Biological was contracted to advise project staff in the collection of distribution data, and to conduct a focused radio-telemetry study on roosting preferences of a few of the rare species. Project staff included existing Forest Service biologists, two seasonal bat specialists hired by the Service for the project, plus numerous volunteers.

While the distribution of all bat species in Southern California is of interest, nine sensitive (former Federal Candidate Category 2) species were chosen as target species for the survey portion of the study and three were chosen as targets for the radio-telemetry study, based on the lack of habitat information for these species (Table 1).

This report attempts to 1) briefly summarize the survey results from one season of surveying for bats within the four Southern California forests (the southern end of the Los Padres, the Angeles, the San Bernardino, and the Cleveland National Forests); and 2) discuss the results of the radio-telemetry study conducted between 3 August and 17 August 1996 in the Laguna Mountains of the Cleveland National Forest.

SURVEYS OF BAT DISTRIBUTION IN SOUTHERN CALIFORNIA FORESTS

Methods

Field work for this study was conducted in 1996 from May through September, in the four National Forests of Southern California. An effort was made to distribute survey sites among the four National Forests and various habitat types represented (Figure 1). The elevation of these survey sites ranged from 340 meters (or 1100 ft.) to over 2300 meters (or 7700 ft.). Over forty sites were surveyed, which included mist-netting or hand-netting bats at water sources, mines, buildings or bridges, and listening for both audible and ultrasonic bat echolocation calls. Echolocation signals were monitored with tunable Ultrasound Advice mini-detectors or Anabat broad band receivers. The latter when coupled with a delay switch and cassette tape recorder could remotely record bat activity. Although these tapes gave limited information on species identification, areas with high levels of bat activity could subsequently be mist-netted.

1996 Southern California Bat Survey Sites

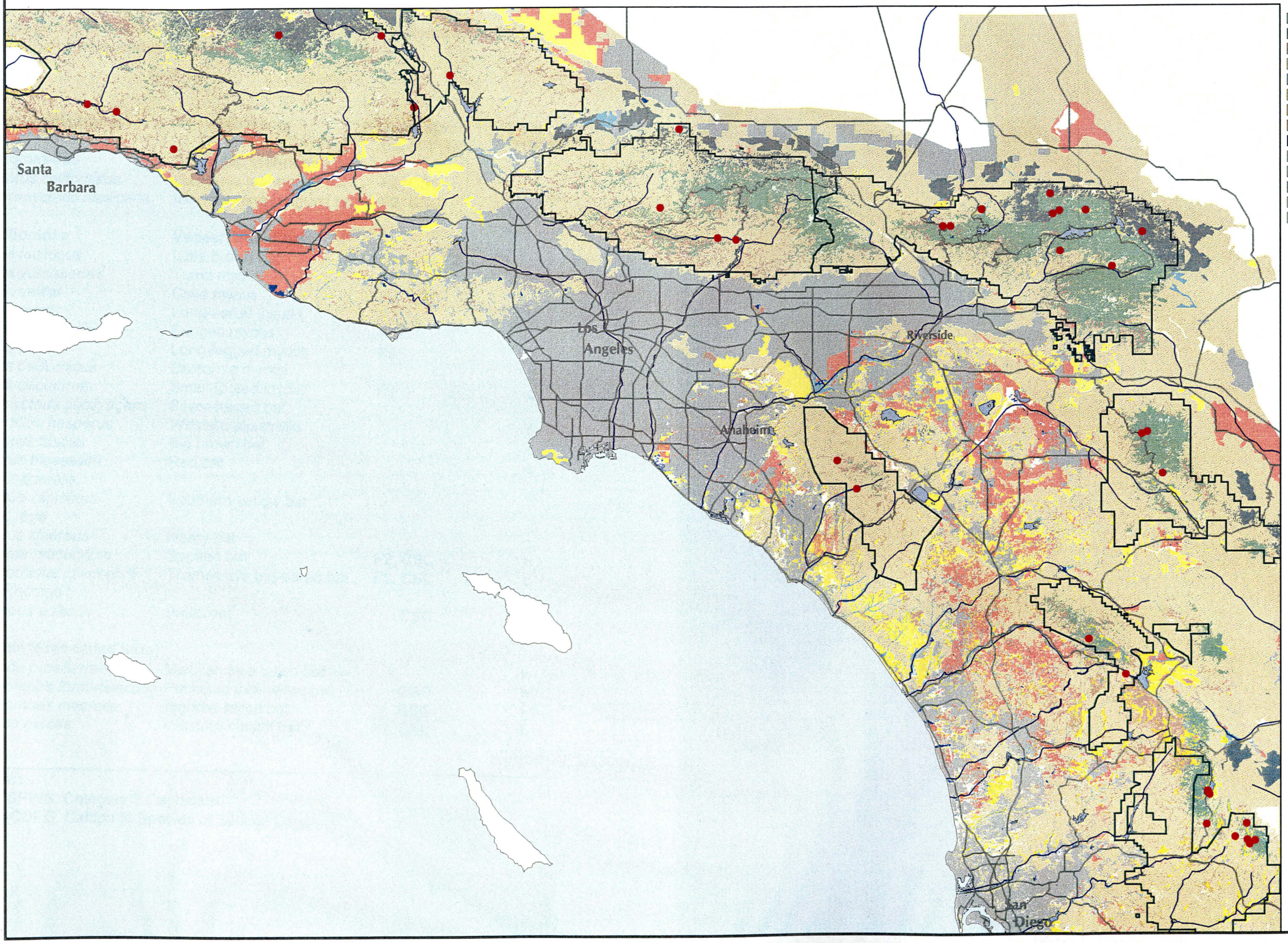


Table 1. Bats of California captured (c) or heard (h) in the National Forests of Southern California during summer 1996.

Family/Scientific Name	Common Name	Legal Status (as of 11/95)	Detected (1996)
Phyllostomatidae	**American leaf-nosed bats**		
Macrotus californicus	California leaf-nosed bat	F2, CSC	
Choeronycteris mexicana	Mexican long-tongued bat	F2, CSC	
Vespertilionidae	**Vespertilionid bats**		
Myotis lucifugus	Little brown bat	(*M.l.occultus* - F2, CSC)	
Myotis yumanensis	Yuma myotis	F2	c
Myotis velifer	Cave myotis	F2, CSC	
Myotis evotis	Long-eared myotis	F2	c
Myotis thysanodes	Fringed myotis	F2	c
Myotis volans	Long-legged myotis	F2	c
Myotis californicus	California myotis		c
Myotis ciliolabrum	Small-footed myotis	F2	c
Lasionycteris noctivagans	Silver-haired bat		
Pipistrellus hesperus	Western pipistrelle		c
Eptesicus fuscus	Big brown bat		c
Lasiurus blossevillii = *L. borealis*	Red bat		c
Lasiurus xanthinus = *L. ega*	Southern yellow bat		
Lasiurus cinereus	Hoary bat		c
Euderma maculatum	Spotted bat	F2, CSC	h
Corynorhinus townsendii = *Plecotus t.*	Townsend's big-eared bat	F2, CSC	c
Antrozous pallidus	Pallid bat	CSC	
Molossidae (Free-tailed bats)			
Tadarida brasiliensis	Mexican free-tailed bat		h
Nyctinomops femorosaccus	Pocketed free-tailed bat	CSC	h?
Nyctinomops macrotis	Big free-tailed bat	CSC	h?
Eumops perotis	Western mastiff bat	F2, CSC	h

Legal Status:
F2 = USFWS, Category 2 Candidate
CSC = CDFG, California Species of Special Concern

Results and Discussion

Over the course of this study, over 400 bats were visually identified, representing 11 different species (Table 1). In addition, a minimum of 4 other species were detected and reliably identified based on audible echolocation calls. These included *Euderma maculatum*, *Tadarida brasiliensis*, *Eumops perotis*, and at least one of the two possible species of *Nyctinomops* (*femorosaccus* or *macrotis*). Eight of the nine target species were either captured or heard during the course of the study. The only undetected target species, *Macrotus californicus*, is currently known only from low elevation desert areas although there are historic records from the coastal foothills of Southern California. It is also interesting to note the fact that the pallid bat, *Antrozous pallidus*, was not captured at any of the sites. Given historic records for Southern California, it appears that this California Department of Fish and Game (CDFG) Species of Special Concern may be on the decline.

The number of sites (out of 41) at which each species was detected is depicted by National Forest and vegetation type category in Table 2. The range of elevations at which each species was found is also listed. Of the bats species that were heard but not captured, only the western mastiff bat (*Eumops perotis*) is listed in Table 2, because it can be reliably identified by all project staff based on its auditory echolocation call. Elevations and vegetation types were assigned to each site using the U.S. Forest Service's Geographical Information System (GIS) database, therefore they may not exactly portray the characteristics actually found at the site. The nineteen vegetation types listed in the GIS database were lumped into seven general habitat types: coniferous forest, riparian woodland, oak woodland, pinyon juniper woodland, chaparral, sagebrush scrub, and grassland meadows. The abundance of each species at a site can not be inferred from this data, since bats were not marked to enable detection of recaptures, and the study employed multiple survey techniques. In addition, some species are more likely to be captured in mist nets, giving a sampling bias to this particular technique. Most netting sites were over water, since for many bat species water is a magnet for drinking and foraging. However, not all species are equally attracted to water sources. Some bats fly too high to be routinely captured in mist nets (i.e. Eumops). This study most likely under represents the distribution of bats in Southern California, because 41 sites is a low sample size given the area covered, and these sites may or may not accurately represent the distribution of habitat. In addition, many of the sites were only sampled once, and bat diversity was seen to increase with repeat sampling at a given site. Furthermore, other studies have found that species composition at particular sites varies from year to year. Several years of repeat sampling may be necessary to accurately describe the bat species composition at any one site.

In spite of the limitations of this one-year study, it is interesting to note the appearance of some species distribution trends. The species most commonly detected throughout the study area was the big brown bat, *Eptesicus fuscus* (found at 51% of the sites), followed by the California myotis, *Myotis californicus* (found at 32% of the sites). Both of these species readily use man-made structures, and have previously been described as common. The rarest species observed were the two *Lasiurus* species (*blossevillii* and *cinereus*), being detected at only 2% and 5% of

Table 2. Species of bats at 41 survey sites in the National Forests of Southern California in 1996. LP = Los Padres NF, A = Angeles NF, SB = San Bernardino NF, and C = Cleveland NF. Sites were assigned elevations and vegetation types using the USFS GIS database. Vegetation categories used here: coniferous forests (cnf), riparian woodland (rip), oak woodland (oak), pinyon juniper woodland (pjw), chaparral (chp), sagebrush scrub (sbs), and grassland/ meadows (grm).

Species (status as of 11/95)		# of Sites	By National Forest				Site Elevations (m.)		By Vegetation Types						
			LP	A	SB	C	lowest	highest	cnf	rip	oak	pjw	chp	sbs	grm
Totals		**41**	8	6	16	11	339	2352	10	2	3	3	12	6	5
Yuma myotis	F2	10	2	2	4	2	472	2352	3	2	1	0	3	0	0
Myotis yumanensis		24%	25%	33%	25%	18%			30%	100%	33%	0%	25%	0%	0%
Long-eared myotis	F2	5	0	0	2	3	1215	2247	2	1	0	1	0	0	0
Myotis evotis		12%	0%	0%	13%	27%			20%	50%	0%	33%	0%	0%	0%
Fringed myotis	F2	3	0	0	0	3	1620	1678	2	0	0	0	0	0	1
Myotis thysanodes		7%	0%	0%	0%	27%			20%	0%	0%	0%	0%	0%	20%
Long-legged myotis	F2	2	0	0	1	1	1678	2027	0	0	0	1	0	0	1
Myotis volans		5%	0%	0%	6%	9%			0%	0%	0%	33%	0%	0%	20%
California myotis		13	1	2	3	7	465	2027	3	1	1	3	0	2	3
Myotis californicus		32%	13%	33%	19%	64%			30%	50%	33%	100%	0%	33%	60%
Small-footed myotis	F2	8	0	1	2	5	512	1967	3	0	0	1	1	0	3
Myotis ciliolabrum		20%	0%	17%	13%	45%			30%	0%	0%	33%	8%	0%	60%
Western pipestrelle		5	2	2	1	0	512	1967	0	0	1	1	1	2	0
Pipestrellus hesperus		12%	25%	33%	6%	0%			0%	0%	33%	33%	8%	33%	0%
Big brown bat		21	0	1	13	7	512	2352	7	1	0	2	4	2	4
Eptesicus fuscus		51%	0%	17%	81%	64%			70%	50%	0%	67%	33%	33%	80%
Red bat		1	0	0	0	1	1643	1643	0	0	0	0	0	0	1
Lasiurus blossevillii		2%	0%	0%	0%	9%			0%	0%	0%	0%	0%	0%	20%
Hoary bat		2	0	0	2	0	1967	2059	0	0	0	1	1	0	0
Lasiurus cinereus		5%	0%	0%	13%	0%			0%	0%	0%	33%	8%	0%	0%
Townsend's big-eared bat	F2, CSC	5	0	0	1	4	1492	1967	1	0	0	1	1	0	2
Corynorhinus townsendii		12%	0%	0%	6%	36%			10%	0%	0%	33%	8%	0%	40%
Western mastiff bat	F2, CSC	7	1	0	4	2	339	2352	3	0	0	0	2	0	2
Eumops perotis		17%	13%	0%	25%	18%			30%	0%	0%	0%	17%	0%	40%
	# of Species		4	5	10	10			8	4	3	8	7	3	8

Note: Vegetation types do not total for Yuma myotis, Long-eared myotis or Big brown bat, because site #120 was typed as "water". See Table 1 for status codes.

the sites, respectively. These two foliage-roosting species are thought to be less common, and possibly more transitory, in Southern California than in the rest of their range. However, evidence is accumulating that indicates statewide declines.

With respect to the four different Forests, species diversity was found to be highest in the better sampled Forests; twice as many species were found in the San Bernardino and Cleveland National Forests which contained twice the number of sites that the other forests contained. Species diversity would likely increase to some degree at all the sites and in all the forests with an increase in sampling. This assumption could also hold for the habitats within which each species would be found. Species diversity was higher in the habitat types which were better represented (8 species in coniferous forests, and 7 species in chaparral). However, it appears that pinyon juniper woodlands, and grassland meadows may be important habitat to a wide variety of species. A small number of sites represented these two habitat types, yet species diversity was found to be as high (8 species each) as was found for coniferous forests and chaparral. It will be interesting to see if these relationships remain after more exhaustive sampling.

Trends in the elevations at which each species are found are also interesting to note. While sites were not chosen to represent elevational gradients and sample size is low, there appears to be some patterns emerging relative to species specific elevational ranges. For example, Yuma myotis, California myotis, big brown bat and western mastiff bat were found virtually throughout the range of elevations sampled. Long-eared myotis, long-legged myotis, fringed myotis, and Townsend's big-eared bat tended to be found at the higher altitudes, and western pipestrelle and small-footed myotis were captured more frequently at the lower end of the range. Care must be taken in interpreting any of this data, however, because some of the apparent trends are confounded by the distribution of the sites. For example, species diversity on the Los Padres National Forest appears to be characterized by four low elevation species, which probably does not reflect the true species diversity for the forest, but rather a possible sampling bias in that 7 of the 8 sample sites were under 900 meters in elevation.

All of the survey data has been entered into a computerized database by the Forest Service, and the locations entered into the GIS. Additional data can be appended and queried in various ways to look at the distributional, elevational and habitat relationships of the bats of Southern California.

LAGUNA MOUNTAINS RADIO-TELEMETRY STUDY

Natural History of Species Telemetered

Myotis evotis evotis (long-eared myotis)

Myotis evotis has a 35.5-41.0 mm forearm, and is distinguished from other myotis by having long blackish ears ranging from 18.0-22.4 mm. in length. The long-eared myotis is distributed from central British Columbia and southern Saskatchewan and Alberta, Canada southward along the Pacific coast to the tip Baja California, eastwardly to the western Dakotas, Colorado, and New Mexico, and ranges from near sea level along the Pacific coast to elevations of 2,830 meters in Wyoming (Manning and Jones 1989). There are two subspecies; *M. e. pacificus*, which occupies the north coastal portion of the range; and *M. e. evotis*, occupying the majority of the range (Hall 1981).

Myotis evotis occurs in a wide variety of habitats over its range, mostly in forested habitat. They have been netted along water courses among deciduous trees, within and along the edges of coniferous forests and in lower-statured plant communities adjacent to coniferous forests. Several accounts mention that they were more abundant in areas which contained broken rock outcroppings or cliffs (Manning and Jones 1989). Females form small maternity colonies in summer (< 40 individuals), whereas males and non-breeding females live singly or in small groups, occasionally occupying the same site as, but roosting apart from a maternity colony. Day roost sites frequently occur in buildings, but also in hollow trees, behind loose bark, in caves or mines, and in crevices in cliff faces, or rocks. Recent studies have found them using small (14 x 46 cm) to medium-sized (53 x 96 cm) rocks on the ground (Morrell et. al. 1996), under bark on stumps in clearcuts (Vonhof 1995), and in shallow recesses at the base of branches of juniper trees (Chung-MacCoubrey 1996).

Myotis evotis eat a variety of insects including Lepidoptera, Coleoptera, Diptera, Neuroptera, Hymenoptera, Hemiptera, and Homoptera, but moths seemed to be more commonly taken. There is some indication of differential selection of prey between the sexes, with males taking a higher proportion of moths than the females (Manning and Jones 1989).

Nothing is known about the winter habits of this species. Presumably, they seek out recesses in mines, caves or rock structures in which to hibernate, and do not migrate far from their summer range.

Myotis thysanodes thysanodes (fringed myotis)

Myotis thysanodes is a relatively large myotis, with a forearm length of 39-47 mm, and is distinguished from other congenerics by the conspicuous fringe of hairs along the posterior edge

of the tail membrane. The fringed myotis is generally found from British Columbia south through the western states and mainland Mexico to Veracruz and Chiapas. Three subspecies are recognized; *M. t. thysanodes* occupies most of the range, *M. t. pahasapensis* occurs as a disjunct population in the Black Hills of Wyoming and South Dakota, and *M. t. aztecus* occupies the extreme southern portion of the range.

M. thysanodes primarily occurs at mid-elevations from 1,200 to 2,100 m. in desert, grass and woodland habitats (O'Farrell and Studier 1980), but has been found at 2,850 m. in spruce-fir habitat in New Mexico and at lower elevations on the west coast of California. Oak and pinyon woodlands appear to be the most common vegetative association, though they have been found in desert and steppe habitats as well as coniferous forests. Day roosts have been found in caves, mines, buildings (O'Farrell and Studier 1980), and more recently in cracks in tall pines (Chung-MacCoubrey 1995, 1996).

One study of *M. thysanodes* foraging habits determined that they fed mostly on beetles. Observations indicated slow, maneuverable flight, with foraging occurring in close proximity to the vegetative canopy (see O'Farrell and Studier 1980).

M. thysanodes is known to migrate, however little is known about the distances moved or the destination of all the migrants. Based on physiology, the distances may be relatively short, to lower elevations or to warmer latitudes, where they can be periodically active in the winter (O'Farrell and Studier 1980).

***Myotis volans interior* (long-legged myotis)**

Myotis volans (the long-legged or hairy-winged myotis) is the largest North American myotis (forearm 35 - 44 mm.) that has a well-developed keel on the calcar. Females are slightly larger than males. One of the most distinguishing characters is that the fur on the underwing extends distally from the body to a line from the elbow to the knee. *M. volans* ranges in distribution from southeastern Alaska to Veracruz, Mexico, and from the Pacific Coast east to the Dakotas and Nebraska. Barbour and Davis (1969) considered this species was "the common Myotis of the western United States and over large areas is probably the most abundant species." There are four currently recognized subspecies; *M. v. amotus* occupies the extreme southern portion of the range, *M. v. volans* occupies Baja California, *M. v. longicrus* is in the northwestern portion of the range, and *M. v. interior* occupies the middle portion of the range.

Myotis volans ranges in elevation from 3,800 meters down to sea level, and is commonly found in the coniferous forests of the Transition and Canadian life zones, but it may also be found in oak and juniper woodland, riparian woodland and desert habitats. *Myotis volans* appears to seasonally shift between habitats (Warner and Czaplewski 1984, Brown pers. obs.). and may be relatively cold temperature tolerant (O'Farrell and Bradley 1977).

Maternity colonies form in buildings or in rock crevices (on the ground or on cliff faces), however, tree roosts (both under exfoliating tree bark and in cavities) appear to be most commonly used (Barbour and Davis 1969, Warner and Czaplewski 1984, Ornsbee 1995). Maternity colonies can be relatively large numbering into the hundreds. Pierson et. al. (1995) found *M. volans* night-roosting under more than half of the bridges they surveyed during the summer near the Sacramento River in Northern California.

The long-legged myotis is a rapid, direct flier, and feeds primarily on moths and other soft bodied or small insects. All components of the vertical structure of the forest appear to be exploited during foraging (Warner and Czaplewski 1984).

Same records indicate that this species hibernates in caves and mines in the northeastern part of the range. Short migrations (probably elevational) to suitable hibernacula are likely.

***Corynorhinus townsendii pallescens* (western big-eared bat)**

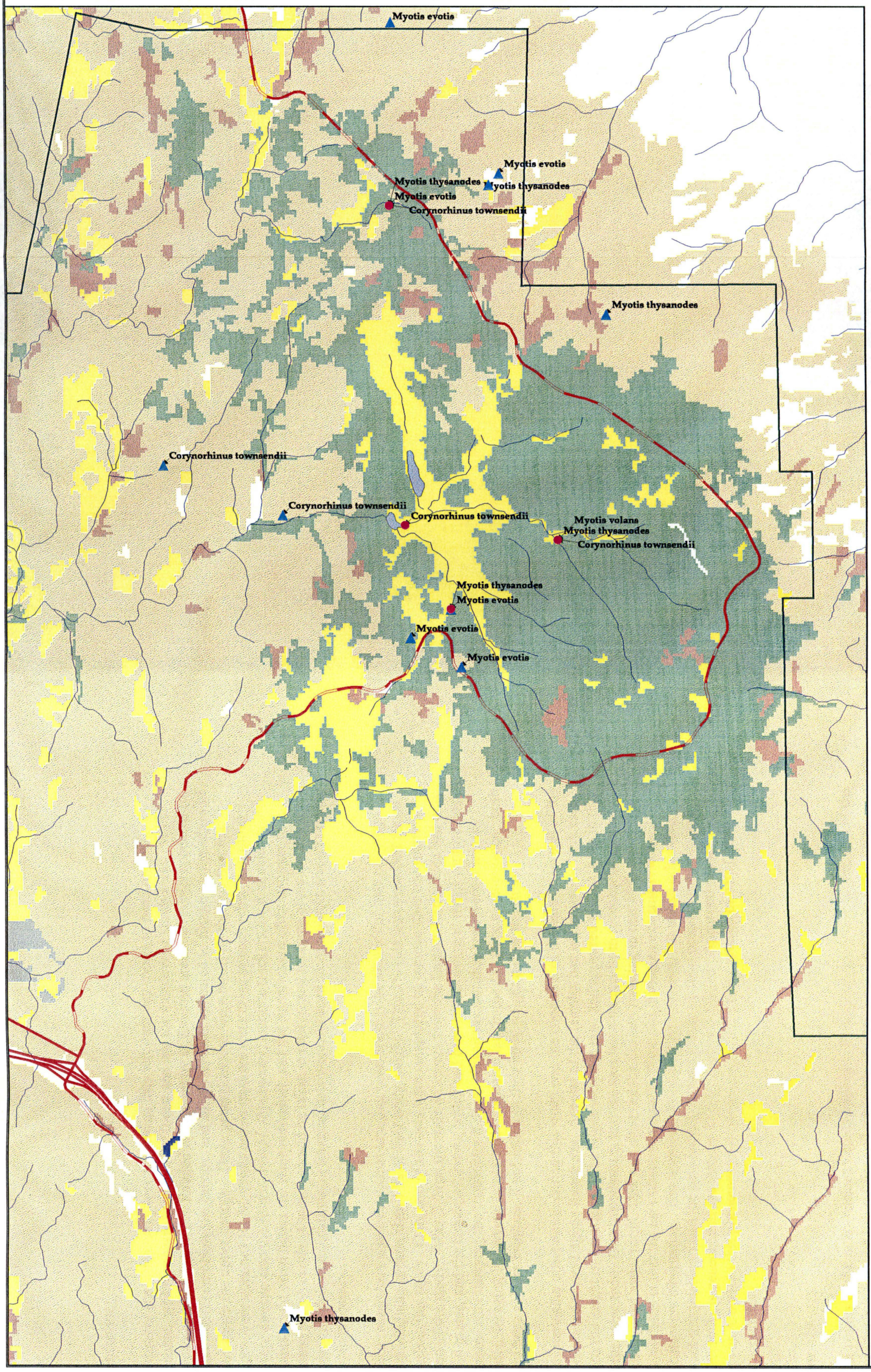
The western big-eared bat is readily distinguished by its long ears (30-39 mm.) and the presence of two fleshy lumps on either side of the nose. Pelage color varies, but generally the dorsal fur is buffy brown and the underparts are lighter. Forearm lengths range from 39-48 mm. *C. townsendii* occurs from British Columbia to southern Mexico and east to Texas, with isolated populations scattered in several of the southeastern states. Five subspecies are currently recognized. *C. t. ingens* and *C. t. virginianus* are the two eastern isolates, and *C. t. australis* occupies most of the Mexico portion of the range. *C. t. townsendii* occurs along the north coastal portion of the range and *C. t. pallescens* comprises the rest of the western distribution, however, there are extensive zones of intergradation for the two western subspecies (Kunz and Martin 1982).

Corynorhinus townsendii occupies a wide variety of habitats, including coniferous and deciduous forests, chaparral, sagebrush and desert scrub habitats, however its distribution is correlated with the availability of caves or cave-like structures (e.g. mines and large boulder piles) on which the species depends for roosting habitat. Elevational distribution for the western subspecies is from near sea level to 2,900 meters.

In California, maternity colonies range up to 400 individuals with a state average of 112 for known colonies, and are located in caves or mines 80% of time. Buildings and other manmade structures are also used (Pierson and Rainey 1994). Caves and mines are also important as hibernacula, and as summer roosts for males and non-reproductive females, and spring and fall transitory roosts for both sexes. *Corynorhinus townsendii* does not migrate and tends to remain faithful to roost sites year after year. Moths are the primary prey, and are taken by gleaning from surfaces.

A hibernaculum and a transient fall roost have been documented for this species in the

Laguna Mountain Bat Study



- Conifer
- Hardwoods
- Chaparral / Scrub
- Riparian
- Grassland
- Urban
- Stream
- Primary Highway
- Secondary Highway
- Lake
- Day Roost
- Capture Site
- National Forest

1 mile

Sources: US Forest Service
Teale Data Center
Scale: 1:50268

Nobel Canyon area of the Laguna Mountains. A corresponding maternity roost for this population has not yet been recorded, but it is likely to be located within the same general area in either a mine or abandoned building.

Methods

The radio-telemetry study was conducted in early August to avoid placing higher energetic demands on lactating females, and yet allow for the likely detection of maternity roosts since the colonies remain intact for about a month after the young are weaned. The Laguna Mountains in San Diego County was chosen as the radio-telemetry study site because both *Myotis evotis* and *M. thysanodes* had been captured there within the preceding month. The Laguna Mountains proved to be an interesting setting within which to study habitat use by forest bats. The study site primarily consists of a string of mountain meadows with ponds in the center, surrounded by a combination of Jeffrey Pine-dominated coniferous forest and Jeffrey Pine/ Black Oak woodland, which is in turn is surrounded by chaparral/scrub type habitat. To the east only a short distance, the topography drops precipitously to the Anza Borrego Desert region of the Colorado Desert.

Preliminary surveys were located both within meadows and within forested habitats, however all of the bats to be radio-tagged were captured at four sites within the forest or near the forest/meadow interface. Three of these sites were at cattle troughs (at the Laguna Ranch, near Water of the Woods, and near Fileree Flat) and one was a night roost in a deserted cinder block pumphouse on Agua Dulce Creek.

Eleven bats had a 0.46 gram Holohil LB-2 transmitter attached with Skin Bond and eye lash cement to a fur-clipped spot between their shoulder blades. All of the radio-tagged bats were adults weighing over 5 grams (usually > 6 g.), including five *M. evotis* (one lactating female, one post-lactating female, and three males), three *M. thysanodes* (one post-lactating female and two males), two *Corynorhinus townsendii* (one post-lactating female and one male) and 1 post-lactating female *M. volans*.

Bats were captured and transmitters affixed throughout the first week of the study, with up to 3 bats being transmittered and released in any one night. After release in the middle of the night, the bats were tracked using various models of portable radio receivers (Telonix, AVM) and hand-held directional antennas to determine the bat's heading and activity. The primary objective of the study was to locate day roosts, and project staff spent late mornings and afternoons trying to locate the bats and/or transmitters by driving or hiking with radio receivers and antennas. At dusk, researchers were distributed throughout the study area on various high points (including Stephenson Peak, Laguna Observatory, Lighting Ridge, and near Garnet Peak) to determine from which direction the bats emerged, and to monitor their foraging behavior. In addition to ground tracking, an attempt to locate roosts from the air was made on two separate days, first using a fixed wing aircraft and two days later a helicopter equipped with outboard mounted antennae.

Results

Day Roosts

A total of 11 different day roosts were located for the telemetered bats: 6 for *M. evotis*, 3 for *M. thysanodes*, and 2 for *Corynorhinus townsendii*. Unfortunately , day roosts were never located for the one female *M. volans*, or the female *Corynorhinus townsendii*. In contrast to previous studies of the three myotis species in other western forested areas, no diurnal tree roosts were located for the radio-tagged individuals in this survey. Three of the five *M. evotis* (including both females) were discovered day roosting under the roofs of buildings; one of the males was found using a fissure in a small boulder on a road cut; and the other two males were located in crevices in inaccessible locations on the rocky escarpment facing east into Storm and Cottonwood Canyons. One of the building roosts, located under the corrugated metal roof of the Laguna Ranch barn, proved to be a maternity colony of approximately 30 individual *M. evotis* when the evening exit was monitored with night vision equipment. The rock crevice roost on the road cut was used by the same lone male on several different days. The same male roosted in a building that was also used as an alternate roost on occasion by the females, but he appeared to roost separately from the females when utilizing the same roost. Tagged *M. evotis* were located night-roosting in the day roosts on several occasions.

All three telemetered *M. thysanodes* roosts were in rock crevices. The males, like two of the *M. evotis*, were utilizing crevices in the upper reaches of Storm Canyon. These roosts were inaccessible, and it was impossible to conduct outflight counts to determine the number of individuals in each roost. The female was eventually located one day in a rock crevice in a large boulder (> 20 feet in diameter), on the southwest-facing side of upper Cottonwood Valley, overlooking Buckman Springs Road and Highway 8. This roost was 12.8 kilometers from her capture site, where she was observed foraging for long periods each night. All of the rock crevice roosts of both *M. thysanodes* and *M. evotis* (except for the road cut) were in chaparral/ scrub habitat, and all were on warm southerly or eastern exposures. Although many of the bats were not located every day, both species apparently switched day roosts from time to time during the course of the study. For example, one male *M. evotis* roosted for three consecutive days in the road cut rock crevice, then moved to a building for a day, moved back to the road cut the following day, then was finally captured at the building the subsequent day.

The male *Corynorhinus* roosted in a shallow rock shelter surrounded by chaparral in lower Nobel Canyon. After being disturbed by the survey team, he moved to another rock outcrop higher in the canyon less than a quarter mile from his first roost. The day roost for the female *Corynorhinus* was not located.

Based on the location of the day roosts relative to the capture or foraging sites, most of the roosts were located away from the forest and the bats commuted to the forested habitat to forage (Figure 2). The distances between capture sites (presumed foraging areas) to day roosts ranged from 20 meters to 12.8 kilometers.

Foraging Behavior

Several of the individuals were tracked as they left their day roosts to head to their foraging habitat, which appeared to be in the forest and not the meadow or shrub areas. While both *M. evotis* and *M. thysanodes* foraged in the vicinity of forested areas, *M. evotis* appeared to forage within the forest below the canopy, and *M. thysanodes* appeared to forage on the edges of the forest or above the upper canopy. These generalizations were based on the fact that few triangulations were obtained for *M. evotis* unless trackers were close to each other, and those headings were directly into the forest. For *M. thysanodes*, multiple trackers located miles apart on high points could often detect the same individual, and the signals were often stronger than those obtained for *M. evotis*. Caution should be taken in interpreting foraging areas for this study, because relatively few triangulations on foraging bats were obtained from multiple trackers taking readings simultaneously.

Some researchers also believe that foraging behavior may be altered for bats carrying transmitters weighing greater than 5 % of their body weight. This 5% rule was exceeded for all of the myotis in this study. Only two of the bats were recaptured to remove their transmitters near the end of the study. After 7 days, the male *M. evotis* from the Laguna Ranch area had only dropped 0.4 grams, and the female *M. evotis*, which had been still lactating at initial capture, lost only 0.1 grams after carrying the transmitter 8 days. Given the fact that both were originally captured after foraging for several hours, and recaptured late in the day prior to emergence, both appeared to have at least maintain, if not added to their body weight during the study.

An interesting observation during this study was the condition of the ears of several of the *M. evotis* captured at the Laguna Ranch site. Several of the females had either one or both ears truncated to the height of the tragus. The edges were not raw, and appeared to have been in this condition for some time. One hypothesis is that the ears were burned from roosting in contact with hot corrugated metal roofs. This was observed for the bats roosting in one of the buildings. Another hypothesis is that the ears where damaged by frost bite during an extreme cold spell while the bats were hibernating. This species is known for its long ears, but unlike other long-eared species it is unable to curl the ears back to conserve heat. A third possible explanation is that the deformity is genetic, and the females of this colony are related. Apparently other researchers have noticed this phenomenon in other areas and for other species of bats (Allen Kurta, pers. comm.)

Discussion

The results of the radio-telemetry study implicate the importance of abiotic features of the environment for bat roosting habitat since all the roosts located were in rocks and not trees. While *M. evotis* have been located roosting in small rocks in other areas (Morrell et. al. 1996, Chung-MacCoubrey 1996), they were also found roosting in trees in the same areas. *M.*

thysanodes have been found primarily roosting in caves and mines, and occasionally trees. This study indicates the geographic variation in roost selection. Often non-vegetative components of the environment are neglected in habitat descriptions (e.g. GIS databases) and habitat suitability models, but these can be critical features that determine the presence and abundance of bats and other animals.

If telemetered bats were roosting in trees then the transmitters should have been detectable during aerial surveys. However, all the roosts located from the air were also detectable on the ground. The day roosts of the bats whose transmitters were not received from an aircraft probably were either in rock crevices (or in mines) in more shielded sites, or outside of the search area.

Trees and snags with appropriate bat roost characteristics (large trees or snags in open areas with cavities, cracks and/or loose bark) are readily available in the Laguna Mountains. *Eptesicus* and *M. ciliolabrum* were even seen using tree roosts during the study. It may be that temperatures in Southern California make tree roosts less desirable for *M. evotis* and *M. thysanodes*. Possibly the bats are selecting rock crevices in sun-warmed sites, because they provide stable roost temperatures, due to the moderating effects of the rock substrate. Kalcounis and Hecker (1995) in a study of roost-site selection in Saskatchewan, Canada, found that summer roost temperatures of *M. lucifugus* in aspen trees were cooler than daytime ambient temperatures, and cooler than daytime temperatures of cavities in conifer snags. Possibly the effect of warm ambient temperatures influenced the selection of cavities in aspen over conifer snags as roosts, with aspens being chosen because the hard outer shell formed in aspen provided a buffer from high ambient temperatures. Vonhof (1995), studying forest bat summer roosting behavior in British Columbia, found that telemetered *M. evotis* were roosting in tree stumps located in south facing clearcuts, but that within the clearcuts they were choosing stump roosts which were cooler and more stable than recesses in randomly selected stumps. These studies suggest that *M. evotis* are choosing cooler rather than warmer sites, or possibly are seeking out a particular range of temperatures.

Chung-MacCoubrey (1995, 1996) radio-tracked *M. thysanodes* and *M. volans* to vertical cracks in live and dead ponderosa pine, and *M. evotis* to live and dead junipers, as well as rocks during a study of summer roosts in pinyon-juniper habitat in New Mexico. The relative exposure of the juniper roosts, (the bat's body was visible at several roosts), suggests that the ambient summer temperatures of this study site did not cause *M. evotis* to choose roosts that provided a temperature buffer. Furthermore, the location of the maternity roost under the corrugated metal roof in the current Laguna Mountain study, makes it appear that this species is choosing extremely warm sites. Measuring the temperatures within random trees, rocks and buildings and comparing them with ambient and actual roost temperatures would be necessary in order to determine if the selection of roosts in the Laguna Mountains is based primarily on temperature parameters. Some benefit must be realized for the bats to select roosts away from their preferred foraging habitat, such as the female *M. thysanodes* that commuted nightly 12.8 km, with an elevational gain of over 500 m, between a rock roost in chaparral to a specific foraging site in

pine/oak woodland.

Regardless of the reason, the availability of crevices in rock outcrops and rocky escarpments will be important variables to consider in the development of habitat suitability models for these species, especially in Southern California. Conservation strategies for these forest and woodland species will likely need to include preservation of these habitat components, which may be located outside the areas typically classified as forests and woodlands.

MANAGEMENT RECOMMENDATIONS

1. Include natural and manmade abiotic features of the habitat (i.e. caves, mines, fractured rocky substrates, buildings, and bridges) when building GIS databases intended for use in developing habitat management strategies for bats.

2. Conduct research to delineate foraging habitat and prey preference since bats are mobile and can roost in areas removed from preferred foraging habitat.

3. Consider that various bat species have different seasonal foraging and roosting requirements, and may undergo altitudinal and latitudinal migrations.

4. Maintain riparian and open water sources, acknowledging that this requirement varies with the species and reproductive condition.

5. Conduct more bat surveys, especially in those National Forests (Angeles and Los Padres) with low numbers and species of bats captured in this study, in order to get a more complete picture of the status and distribution of bats in Southern California.

6. Maintain snags and old growth and manage for the recruitment of same since other research has demonstrated their importance as bat roosts (although not for the individuals studied in the current telemetry study).

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